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ABSTRACT

This paper presents a CD-ROM computer tutorial titled "Higher Mathematics," that contains 17 educational mathematical programs and is intended for use in Russian university engineering education. The first section introduces the courseware climate in Russia and outlines problems with commercially available universal mathematical packages. The second section describes the structure and properties of the courseware, including the following components: (1) MATRIX, a subject-oriented program that provides computer support to the study of linear algebra and analytical geometry; (2) FORMULA, a subject-oriented medium for solving problems in calculus and approximate calculations; (3) ODE (Ordinary Differential Equations), a program that helps in understanding qualitative aspects of the theory of differential equations; (4) Numerical Integration; and (5) the courseware navigator. The potential to run the courseware package on the Internet as well as on a local network, and plans for future development are also discussed. Five figures illustrate the main dialog window of MATRIX, the graphic window of FORMULA, the graphic window of ODE, a screen in the package Numerical Integration, and a Navigator menu. (DLS)

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Computer Tutorial "Higher Mathematics" for Engineering Specialities

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Abstract: In the article the computer tutorial "Higher mathematics" for engineering specialities of universities is represented. The tutorial includes 17 computer programs of educational purpose. The programs of the package allow to solve practically any problem from higher mathematics course. The package is prepared on CD-ROM.

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1. Introduction

It is hard to find in Russia a university, an institute, a faculty (humanitarian, natural science, engineering), where the attempts are not undertaken to use modern computer technologies in educational process. Small creative groups (1-3 participants) make a lot of computer tutorials intended for educational purposes. Many unstate organizations create such programs as well.

Representing a new Russian courseware, computer tutorial "Higher mathematics" for engineering specialities, the authors would like to tell about one of the approaches to the problem of "computer in education", which is realized in this tutorial.

The situation with the use of computers in education is paradoxical. On one hand, the computer programs of educational purpose were developed always and everywhere. From the very beginning of computer era, as soon as a working electronic computing device appeared at school, high school, research institute, there was at least one person there (enthusiast, the fanatic, maniac) who started creating computer programs intended for tutoring. On the other hand, in reality computers are used in tutoring very little (except computer science), and, as a rule, it is done by developers themselves or their colleagues. Why? Such self-made programs usually support the study of rather small part of the course, they are strictly limited by a concrete technique of teaching (material presentation), by concrete educational plan, and usually they are badly documented or have no appropriate methodical documentation at all.

The situation with the use of universal mathematical packages, such as Mathematica, MathCad, MapleV, Derive, MatLab etc. in education is similar. These programs are attractive by their high-power graphic and computational capabilities, and by the possibility to make analytical transformations (symbol calculations). The teacher who masters the package of that kind, as a rule, can effectively use it in tutoring. On the base of universal packages special educational programs are created (for example, StudyWorks is created by MathSoft on the base of MathCad), and the tools for creation of educational courses are developed. However, in spite of the fact that the mathematical packages are known long ago and are rather widely spread, it is too early to speak about adequate use of them in educational process. Why? Since these packages initially were developed to support scientific and engineering researches, their interface is badly adapted for educational purpose. So there are problems in mastering a package (the user, the student or the teacher, should learn the interface or command language of a package). The efforts to master the interesting part of the problem (from the point of view of the subject under investigation) are often comparable to energies spent on a solving of technical problems, concerning the method of a problem notation and interpretation of results in a medium of a concrete package.

Though the market of computer programs of educational purpose is extremely poor, the demand for them grows. A few programs available either decide particular problems (teaching English, increase of grammatical correctness, teaching arithmetic etc., i.e. they are oriented mainly on children before 12 years), or have no adequate methodical support. The appearance of tutoring CD-ROMs hasn't changed the situation (as a rule, it is English for kids and teenagers, children's encyclopedias, museums, historical and geographical excursions, fragments of mathematical courses for junior school, teaching games).

For several years the seminar "Computers in mathematical education of engineering specialities" works on

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the faculty of higher mathematics in Moscow Power Engineering Institute. A great number of various computer programs of educational purposes in mathematics, physics, mechanics, programs for schools and high schools, both authorship and created on the base of universal packages, were discussed at that seminar. At the same time in Informational Systems Research Institute of Russia the fund of computer tutorials was analyzed. As a result of these discussions and analysis it was possible to work out a constructive approach to a problem.

This approach consists in attempt to unit the existing educational mathematical programs realized by different authors, in a package on a uniform methodical basis in aim to receive a full computer support of higher mathematics course for engineering specialities, i.e. the computer program, which will assist in teaching of this course.

By results of expert examinations and experimental operation 17 educational mathematical programs created in leading Russian universities were selected. Put together, these programs enable to solve practically any problem from the course of higher mathematics for engineering specialities, and the students often escape laborious calculations and get the visual graphic interpretation of results. In Informational Systems Research Institute of Russia selected educational mathematical programs were incorporated in a uniform package. The staff of the institute and the authors of the programs carried out the task using tool system HM-Card (see below).

The package can be useful to the system of education as a whole, since it contains all necessary tools for introduction of the computer in process of teaching of higher mathematics on a complex basis, that will allow to increase efficiency of teaching process.

The package can be useful to the teachers, since it contains only tools for problem solving and the methodical part of its application is completely determined by the teacher. Thus, the package is free from methodical dictatorship of any kind.

The authors hope, that the package will be useful to students, for it contains not only tools for problems solving, but also demonstration programs showing how to solve a problem.

The created package of educational programs can be called a computer tutorial for higher mathematics, the tutorial assisting in mastering the course of higher mathematics with the help of computer.

One of the main properties of an offered package is that it combines works of different authors for complex computer support of the study of mathematical disciplines. The package is open for inclusion of diverse programs assisting the study of mathematical disciplines. Each work of the authors from different schools can be put on a certain "methodical shelf". It will allow students and teachers to choose and to use in the study of the subject such tools that suit them. The package is also open for connection of any universal mathematical package, that enable to create a highly effective medium for study of mathematical disciplines including both educational programs, and universal packages.

2. Structure and Properties of the Courseware

The computer tutorial for engineering specialities is the library of educational mathematical packages and Navigator for the course of "Higher mathematics".

The library consists of computer programs of educational purpose, developed in the leading Russian universities.

Educational mathematical packages "FORMULA", "MATRIX", "ODE — Ordinary Differential Equations" are developed in Moscow Power Engineering Institute (MPEI) on the Department of higher mathematics by collective of authors: Kirilov A.I., Slivina N.A., Chubrov E.V., Demushkin A.S., Morozov K.A.

Labs on computational mathematics is created on the Department of Computational Mathematics in Moscow Institute of Physics and Technology (MIPT). The scientific principal is Ryabenkii V.S. The group of authors: Petrov I.B. (supervisor), Ivanov V.D., Korotkin P.N., Kosarev V.I., Pirogov V.B., Severov D.S., Tormasov A.G., Ustyuzhnikov S.V.

Computer system of control of knowledge in higher mathematics "Ordinary differential equations" is developed in Moscow State University (MSU) at the Department of Differential Equations. The authors: Baula V.G., Lokshin B.J. Rozov N.C., Sushko V.G., Shikin E.V.

Subject-oriented educational package "MATRIX" provides computer support to the study of linear algebra and analytical geometry. In [Fig. 1] the main dialog window of "MATRIX" is represented. The package enables a user to investigate a wide range of exact and approximate algorithms of linear algebra.

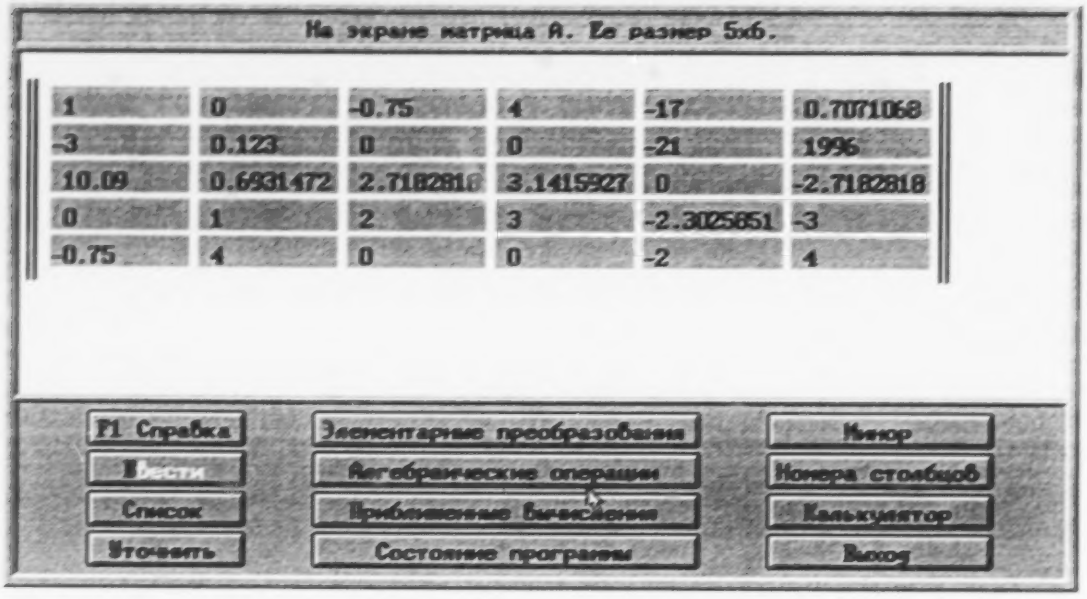

Figure 1: The main dialog window of "MATRIX". The switching of modes is done by one click of the mouse.

Package "FORMULA" is a subject-oriented medium for solving problems in calculus and approximate calculations. The program has broad computational and graphical capabilities. "FORMULA" enables to perform diverse calculations, from arithmetical expression evaluation to special functions and partial sums evaluation, and symbol differentiation of functions of one or several variables. The analytical and graphical capabilities of the package completely cover the needs of classical calculus course. The friendly interface and effective organization of computing procedures allow to illustrate and to investigate rather complicated models. In [Fig. 2] the example of trigonometrical series investigation is shown.

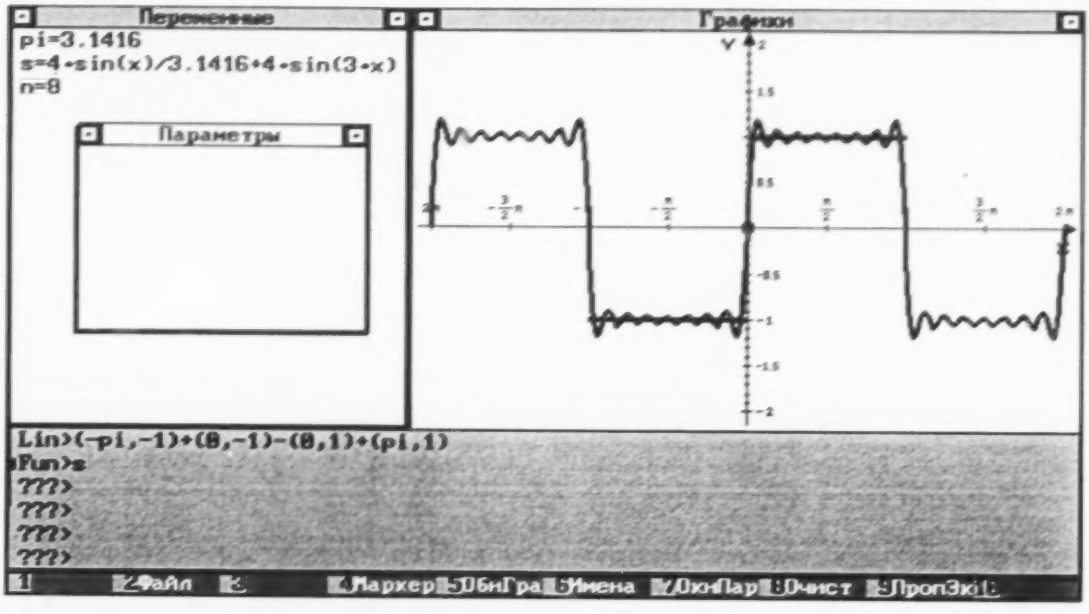

Figure 2: The graphic window of "FORMULA". The next harmonics is added by pressing of one key.

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The main purpose of the package "ODE" is to help in understanding of qualitative aspects of the theory of differential equations by consideration of many meaningful examples and solution of many problems, which are hard or sometimes impossible for student to solve without computer. The package allows to input and to investigate any differential equation or system of differential equations up to the sixth order inclusively. The package has the friendly and logical interface. [Fig. 3] shows the phase portrait of an autonomous system: .

$$x' = x(x^2 + y^2 - 1)(x^2 + y^2 - 4) - y, y' = (y(x^2 + y^2) + x/3)(-4) + x.$$

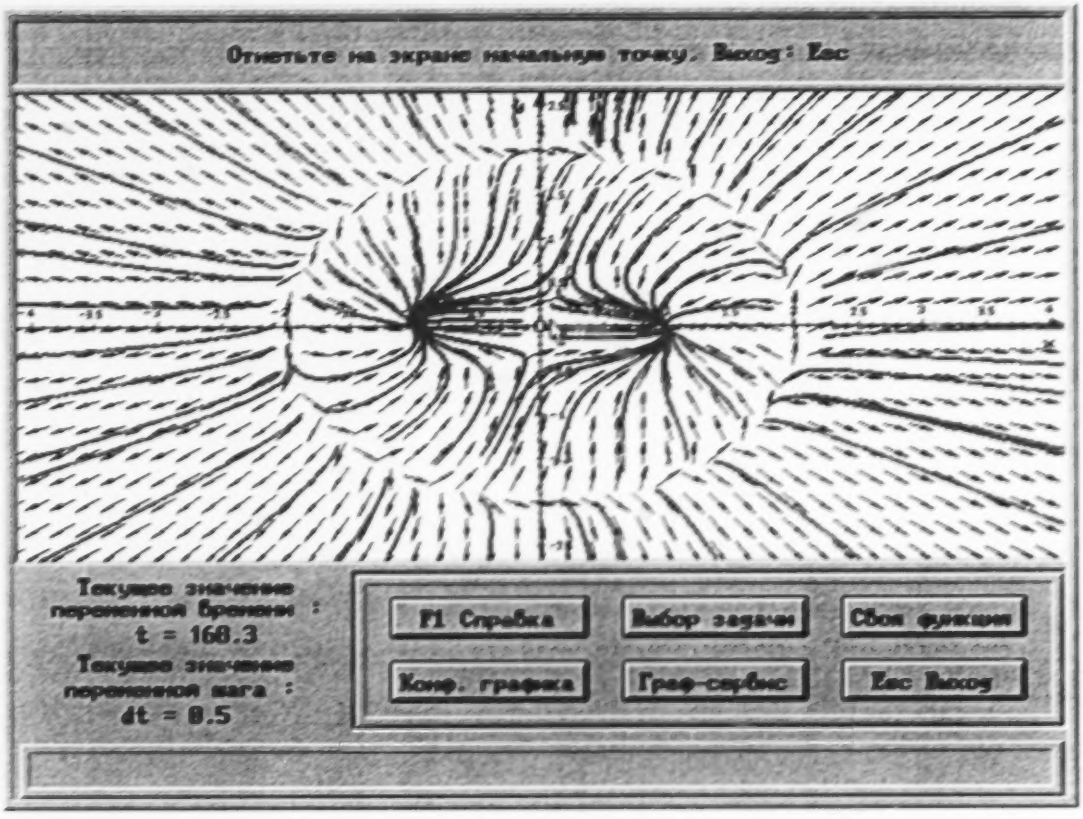

Figure 3: The graphic window of "ODE". The phase portrait is built by several clicks of the mouse.

The labs in computational mathematics enables to master the known numerical methods traditionally used in solution of scientific and practical problems. The package instills skills of investigation of numerical algorithms properties, helps to understand the boundaries of their preferable applicability. The graphic capabilities of the programs in the package and well thought-out distinct interface, uniform for all the programs, allow to learn characteristic effects arising in a numerical solution of practical problems in clear and visual form.

Besides the course of computational mathematics the labs can be effectively used in the study of calculus, linear algebra, differential equations and equations of mathematical physics.

On [Fig. 4] the screen during the work with the program "Numerical integration" is shown.

The computer system of control of knowledge in higher mathematics "Ordinary differential equations" is a remarkable problem book containing over 300 problems, composed by the noted experts on differential equations, qualified teachers with long-term experience in teaching of differential equations at Moscow state university.

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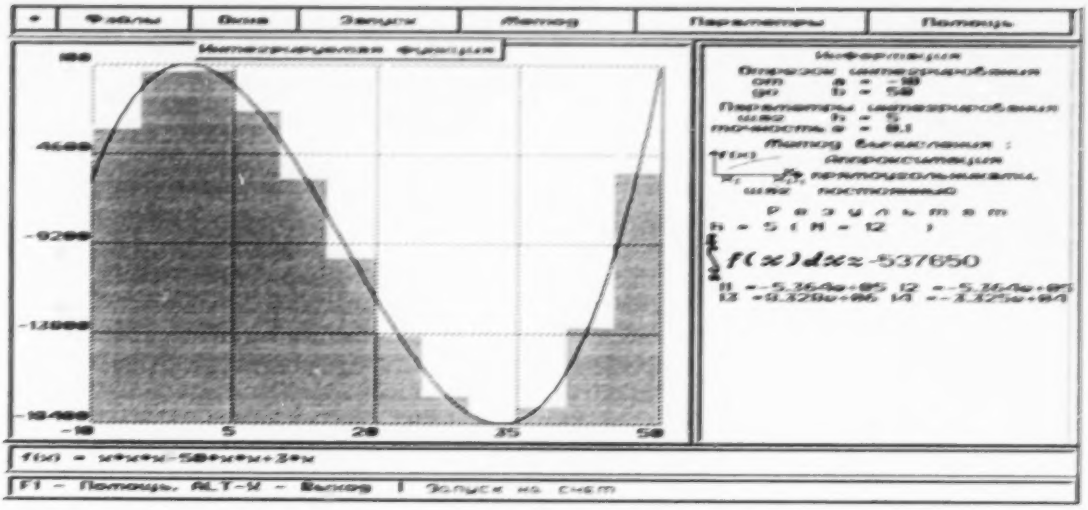

Figure 4: A screen in the package "Numerical integration".

The navigator of the courseware is constructed as a hierarchical menu that permits to move through sections, subsections and topics of the course of higher mathematics for engineering specialities. Besides, the Navigator introduces main functions and technique of work with each educational mathematical package from the library. It helps to understand how to apply a concrete educational mathematical package for solution of the problem from the course of higher mathematics. To reach this goal over hundred examples of solutions of typical problems from standard problem books are included in the Navigator. The examples are executed as demonstrations with detailed explanation of the course of solution. The menu of the lowest level consists of two parts: the list of problems, that can be solved within the framework of the concrete topic, and the title of an educational mathematical package from the library, that helps to solve the problems in the given topic [see Fig. 5]. The navigator allows the student to keep to the studied course, to receive an information about methods of solution of typical problems from demonstrations and to call for a solution of the problem just that educational package, which suits this purpose in the best way.

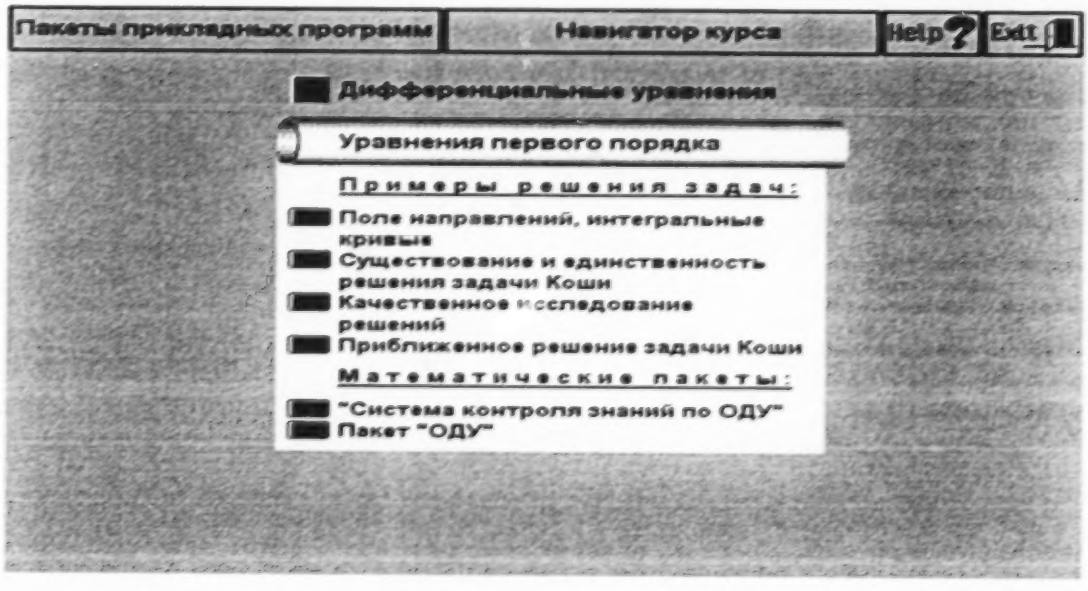

Figure 5: Navigator. One of the menus of the lowest level.

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Navigator helps to receive enough information on the work with a concrete educational mathematical package: to read the author's summary, to start a demonstration, or to take advantage of the built-in help by starting a concrete package. The tutorial is accompanied by four books (user manuals and methodical instructions).

3. The Tool of the Courseware Creation

The navigator of the courseware is realized with the help of multifunctional tool hypermedia system HM-Card. This tool system developed at Technological University of Craz (Austria), is primary oriented on creation of educational computer programs of various types.

4. Perspectives of Use in the Net

The toolkit system HM-Card, by which Navigator is produced, allows to create packed files with an image of software for transfer in the net. The educational software can be located both in the Internet and on the server of a local network of the university. To run the program on a local workstation Netscape Navigator can be used. The demo-version of the tutorial is published on the WWW-server of ISRIR for free access (http://www.riis.ru).

5. Conclusions

The presented computer tutorial is the first courseware of such class in Russia. The authors hope, that it will help the teachers (to prepare lecture and seminar demonstrations and tests, to give lessons in computer class and to develop of new modern courses), and students (to investigate a subject under the direction of the teacher, to work independently or to deepen their knowledge). Note that all the programs are used by the authors for a number of years in real educational process, as well as in scientific researches and methodical work; these programs are used by the students for self-education and in preparation of degree works and, that is very important, in different universities.

The method applied for creation of the computer tutorial in higher mathematics allows to build blocks of uniform computer support of courses of any educational discipline.

The navigator of the computer tutorial in higher mathematics is open for updating: it is possible to expand the list of sections and topics, to include new educational packages, to enter in the menu of the concrete unit some programs with close capabilities. Thus, the courseware can be built up by integrating developments of various universities, high schools and concrete authors. This approach allows to create by common gains an educational software, which is meeting the requirements of significant number of students, and to avoid so-called methodical dictatorship of single school or direction. The students will have an opportunity to select the most suitable tool from several educational resources.

The authors see in pilot-project of the computer tutorial on higher mathematics the probable prototype of the similar projects on other disciplines. The work on upgrading the tutorial goes on.